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How Technological Progress and Government Programs Influence Agricultural Land Values

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In this report...*Technological change mitigates the upward pressure on land values caused by growth in population and other factors by increasing the "effective" supply of land. Without technological change during the postwar period, land values would be substantially higher. Government acreage reduction programs, by creating an artificial scarcity of land, have counteracted some of the effects of technological change and placed upward pressure on farmland values.*

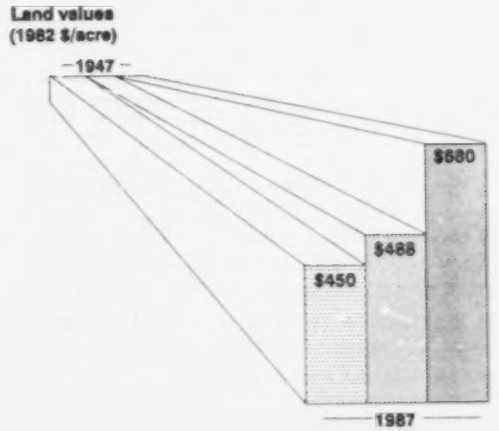
Agricultural land values in the United States increased 75 percent in real terms (adjusted for inflation) from 1947 to 1987. Land values are affected by several interrelated economic forces. This report examines the mix of forces that have led to the longrun increase in land values, with a focus on the effects of technological progress.

Real farmland values have risen since World War II, even though agriculture's relative importance in the national economy has declined. The primary sources of the longrun growth in real land values are worldwide population growth, overall national economic growth, and the associated rise in national wealth. Federal agricultural support programs have also played an important role in maintaining agricultural land values.

Technological progress has partially counteracted some of the forces that have raised land values. Because technological advances increase productivity and effectively raise the supply of land, growth in land values is slowed. Technology has reduced the need for land in agricultural production relative to other inputs, thus tending to hold down land prices. But the increase in productivity can also have the opposite influence on land values, if the gain in productivity improves the competitiveness of U.S. exports and enhances U.S. market share overseas.

Figure 1 presents trends in real land values between 1947 and 1987. If there had been no technological progress, the land value trend would have been higher, with values in 1987 possibly 20 percent higher. Land values might have been much lower in the absence of Government acreage reduction programs.

Figure 1—Technological progress, Government programs, and the value of land.
Technological progress tends to reduce land values, while Government programs raise land values.



What land values would have been in 1987 if there had been no technological progress since 1947.

Land value per acre (1987).

What land values would have been in 1987 if there had been no acreage reduction programs.

Based on: Offutt and Shoemaker, 1988

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Agriculture's Relative Importance in the Economy Has Fallen, But Not Land Values

Farmland's importance in aggregate production and total national wealth has declined historically. Real agricultural commodity prices, which influence land values, have also decreased. Yet farmland values have increased.

Commodity prices and productivity directly determine land values. Population, productivity growth, wages, and prices determined outside the farm sector affect agricultural commodity prices and productivity, and indirectly influence land values. While indicators such as agriculture's declining share of gross national product (GNP) suggest farmland values should fall, the growth in agriculture and the economy as a whole has increased land values. That is, agriculture as a portion of the national "pie" has shrunk, but the pie has grown, raising land values.

Agriculture in National Economic Growth. Agriculture has always been a significant source of growth early in a nation's economic development. Figure 2 indicates that land was a primary source of wealth and a major input in aggregate production early in U.S. economic development. At the time of our independence from England, all land in the United States accounted for approximately 41 percent of total national wealth, whereas now it represents only 12 percent. Even though the quantity of land has actually grown through territorial acquisition and real land values have risen, the quantity and value of other reproducible assets have grown considerably more.

The decline in land's share in total national wealth indicates that the value of agricultural production has not grown as fast as other economic sectors. In the early 1800's, agriculture represented about 70 percent of national output. By the turn of the century, agriculture's share of output had fallen to a little over 30 percent. In 1987, agricultural output represented only 2.2 percent of GNP.

Agriculture's importance in GNP declined because society became more affluent and the demand for farm products relative to nonfarm products diminished. In the United States, food consumption as a percentage of disposable income fell by half between 1929 and 1987. The decline in relative demand for farm products lessened agriculture's claim on all of society's resources.

The inevitable result of the decline in consumption of agricultural products *relative to other goods* was:

- Real agricultural commodity prices fell,
- Percentage of national resources devoted to agriculture declined, and
- Farm income as a percentage of national income declined.

Table 1 shows the steady drop in farm income's share of total national income. Farming's share of national income has fallen 75 percent since the end of World War II. In contrast, it took almost 100 years, from 1800 to 1900, for agriculture's share of national income to fall 50 percent, from 43 to 20 percent. So, while in absolute terms farm income has grown, in relative terms its share of total national income has declined.

The fall in the importance of land and agricultural production is accelerated whenever the relative importance of agriculture in the economy diminishes *and* other factors are substituted for land in farming. As the share of land in agricultural production falls relative to other inputs, land's importance to society as a source of wealth diminishes further. But despite the decline in the relative importance of agricultural land in national wealth, the real price of land has risen over time.

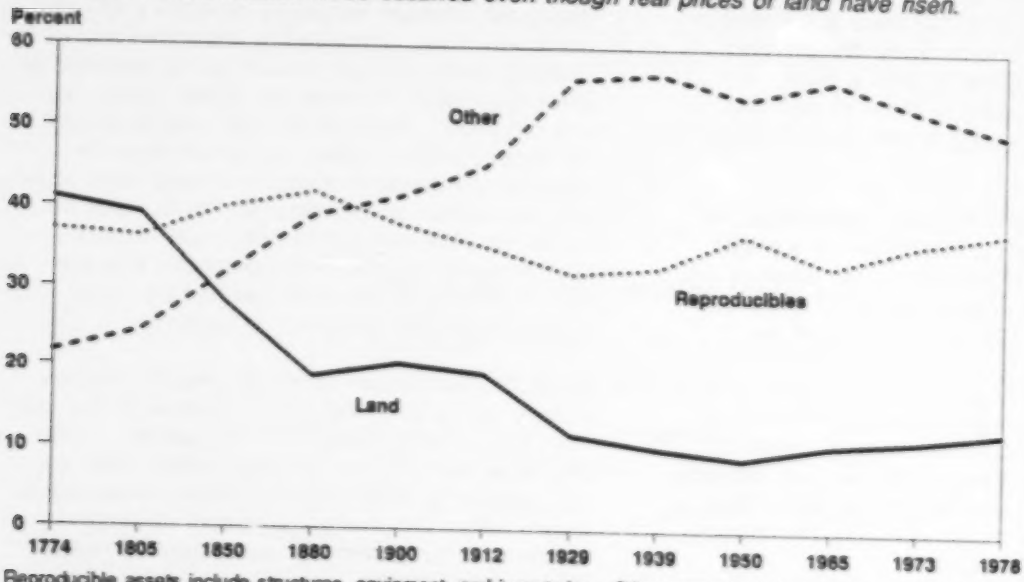
The above considerations point to a slowing of the growth in demand for farm products (in developed economies) even though the population continues to grow. Farm productivity growth increases agricultural supplies, which for the United States have been in surplus. The result is declining real agricultural commodity prices (table 2).

U.S. Economic Growth Raised Farmland Values. The United States has enjoyed considerable real economic growth since World War II. U.S. real GNP grew at an average annual rate of nearly 4.5 percent from 1947 to 1987, while population grew at a rate of only 1.3 percent per year (table 2). These two rates imply that real income per capita has risen over this period, which in turn implies an increase in real national wealth. Agricultural land values share in the overall expansion of wealth. While overall increases in national income result in

a declining share of national income devoted to agriculture, the returns to agricultural resources still benefit from economic growth. Even though the agricultural slice of the national income pie shrinks, the pie itself grows, and hence returns to all factors, farm and nonfarm, rise.

Despite the decline in the prominence of agriculture in national income and the decline of the share of land in agricultural income, the real value of land has increased. Agricultural land values have grown 75 percent in real terms (adjusted for inflation) from 1947 to 1987.

Figure 2—Land's contribution to total national wealth declined relative to other assets, 1774-1987.
This loss in land's relative value occurred even though real prices of land have risen.



Reproducible assets include structures, equipment, and inventories. Other assets include monetary metals and financial assets. Source: Raymond W. Goldsmith, *Comparative National Balance Sheets, A Study of Twenty Countries, 1688-1978.* Chicago: University of Chicago Press, 1985.

Table 1–Farming's historic share of national income.
The steady decline in farming's share of national income has tended to reduce land values.

Year	National income	National farm income	Farm income's share of total
	——Billion dollars——		Percent
1799	0.7	0.3	42.9
1849	2.3	.7	30.4
1879	6.6	1.4	21.2
1900	14.6	3.0	20.5
1920	61.0	10.6	17.4
1929	86.4	8.4	9.7
1939	64.2	5.9	9.2
1949	215.2	16.1	7.5
1959	409.2	14.6	3.6
1969	798.1	21.2	2.7
1979	2,047.3	53.4	2.6
1983	2,719.5	41.7	1.5
1987	3,678.7	66.1	1.8

Sources: U.S. Dept. of Commerce, *Historical Statistics of the United States, Colonial Times to 1957,* and Survey of Current Business, *National Income and Product Accounts.*

Table 2–Farm sector growth compared with total U.S. growth.
National economic growth and growth in farm returns have outweighed the drop in commodity prices and the gains in productivity that tend to depress land values.

Item	Real average annual growth, 1947-87
	Percent
Farm:	
Farm productivity	2.0
Farm commodity prices	-1.4
Returns to farm assets	1.9
Land values	2.9
Total United States:	
Gross national product	4.5
Population	1.3

Supply and Demand Set Land Values

Since the total supply of land is fixed, higher demand for land almost always raises land values. Buyers' expectations about the income to be earned from the land are crucial in determining land values.

Agricultural land values are determined by the supply and demand for land. Land is different from other commodities in that there is a limited or fixed supply of land, and its useful life is almost limitless. Since the supply of land is fixed, increases in the demand for its services can only result in higher land values, unless there is technological progress.

Population Growth Is a Primary Determinant of Land Values. A growing population on a planet with a fixed amount of resources puts pressure on those resources. Worldwide population grew over 60 percent between 1961 and 1986 while the growth in worldwide agricultural land was only 9 percent (table 3). This growth in population puts particular pressure on nonreproducible resources such as land. The increased demands made on land in the face of a fixed supply can only increase its value. Population growth coupled with a fixed supply of land is the primary longrun determinant of the growth of land values.

Land Values Depend on Expected Income From the Land. The demand for land and land values are largely determined by the expected earnings from the land. Land values represent the present value of the expected future income earned from land. This definition for land values consists of three parts: (1) the income earnings or productive capacity of the land, (2) the expectations of those earnings, and (3) discounting those earnings from the future back to the present. Land values correspond to land earnings because a person would not pay more for a piece of land than what the land could earn. Earnings depend on commodity prices and the land's productivity. Higher valued commodities and highly productive land boost land values. Changes in the expectation of commodity prices or productivity change the value of land and create capital gains or losses.

Expectations Affect Land Values. Expectations are crucial for determining land values. Since buyers cannot know with certainty what the future holds for commodity prices and other factors that determine land returns, they must make their own forecasts. The types of expectations people have can, in turn, affect land values.[1] Expectations of future prices based solely on current or recent prices can be erroneous because they may not distinguish between temporary changes and more permanent ones. For example, increased returns resulting from a drought should not be expected to affect land values because the higher returns are only transitory. After the drought, returns should fall back to normal levels. Permanent improvements in the quality of a parcel of land, such as an irrigation system or terracing, add to its value because the increased productivity raises expectations of future returns. Farm programs that support commodity prices raise land values if landowners expect the programs to continue.

While farmland values reflect the income from the current use of land, the expected value of alternate uses is also incorporated into land prices. In the Northeast, for example, farmland values often are high relative to other regions. Higher Northeastern values reflect the potential for future development in nonagricultural uses that would provide higher returns than farming.

Interest Rates Convert Future Land Earnings Into Current Land Values. Land, as a form of wealth, is expected to earn income over a long period of time. Except for some intrinsic qualities that land may have, the desire to own land is based on an expectation of earning income in the same way a return is expected from owning a bond or any other income-earning asset. The value of an asset is determined by the asset's earnings over time discounted by some interest rate back to the present. Future earnings are discounted because individuals generally prefer to have their earnings now rather than in the future. The higher one discounts future earnings, the lower the asset's value, and vice versa. The interest rate used to discount an asset should reflect both how long one is willing to wait for the earnings and the rate of return offered by alternative investments. Because we want to compare assets' real earnings, exclusive of inflation, the interest rate used should be net of the inflation rate, that is, the real interest rate.

[1] Types of expectations can vary from naive expectations, where individuals expect the immediate past to persist, to rational expectations, where due to some additional information individuals are able to make more accurate forecasts.

Main Factors That Determine Land Values

- Income currently earned from land, which in agriculture depends on expected commodity prices, how productive the land is, and how much the Government supports farm income.
- Expectation of future income earnings, either in agriculture or in alternative uses.
- Discounting earnings from the future back to the present.

Table 3–Worldwide population growth and land.
Population pressure on land is the primary longrun factor raising land values.

Year	World population	Agricultural land[1]	Density
	Millions	*Million hectares*	*Persons/ hectare*
1961	3,091	1,349	2.3
1970	3,721	1,408	2.6
1980	4,476	1,454	3.1
1986	4,967	1,474	3.4

[1] Agricultural land is arable and permanent cropland.

Technological Change Slows Growth in Land Values

Technological progress increases the effective supply of land by enabling a unit of land to produce more, thus increasing the supply of agricultural commodities over time. Without technological change during the postwar period, land values would be substantially higher.

Technological progress counteracts some of the forces that tend to raise land values, such as worldwide population growth and overall national economic growth. Economic analysis indicates that land values would be significantly higher without the effects of technological change.

The Role of Technological Progress. Technological progress has the effect of increasing the services from a unit of land by allowing more output per unit. In effect, technological progress increases the supply of land, and thus mitigates the upward pressure on land values that comes from increases in the demand for land. Population growth will continue to cause land values to rise, but technological progress will slow the rate of growth.

Technological progress also affects the value of agricultural products and therefore indirectly affects land values, since land values are determined by the expected earnings from land. For a given resource base, technological progress increases the supply of agricultural commodities over time. Worldwide population growth and the resulting growth in export demand increase the demand for agricultural products. But, as long as the growth in supply due to productivity growth exceeds the growth in demand, real returns will increase even though real commodity prices will fall. Figure 3 demonstrates this case. Here supply has grown more than demand, resulting in a drop in commodity prices and an increase in commodities produced. The shaded area represents the returns to land. Area A represents the initial returns. These returns accrue to land (or a portion of the returns, depending on certain assumptions). Area B, which shows returns after the growth in supply and demand, is larger than area A, indicating that total returns have increased.

Historically in the United States, supply has grown faster than demand, resulting in declining real commodity prices. Despite the decline in real commodity prices, increases in both supply and demand have raised the total return to agricultural assets. The rise in real returns over time and the fixed supply of land tend to raise land values.

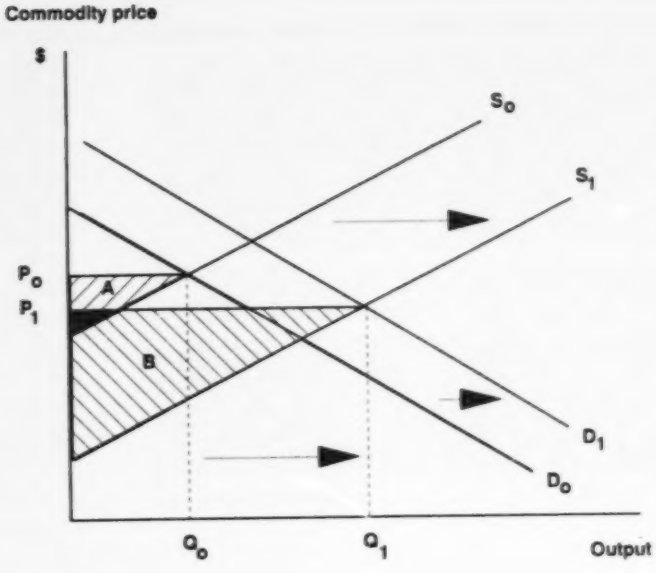
What would be the value of land in the absence of technological progress? Put another way, how important is technological progress in determining agricultural land values? Estimates derived from a previous study suggest that during the postwar period, land values could have been at least 20 percent higher on average without the effects of technological change. (See Offutt and Shoemaker, 1988.)

Figure 3—Returns to land and land values increased as *both* supply and demand for agricultural commodities increased.
Technology has boosted the supply of commodities while population growth and export demand have increased demand.

Returns to land

A. Before the increase in supply and demand.

B. Returns to land are greater because both supply and demand increase.



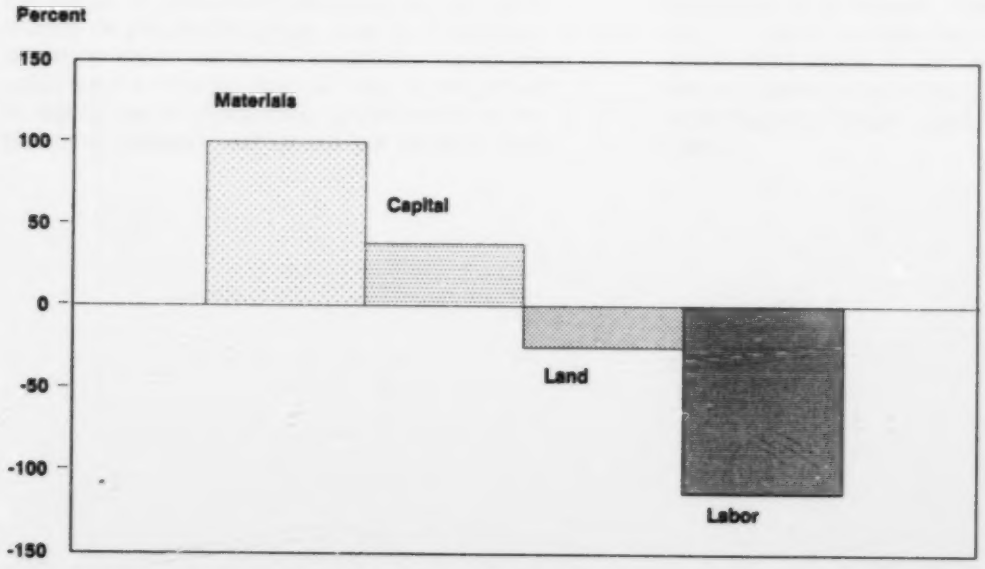
Technology Has Varying Effects on Agricultural Inputs

Technological change reduced the need for labor and land, but increased the use of agricultural chemicals and farm machinery in U.S. agricultural production.

Technological change affects production unevenly, in that it affects only one or a few inputs. This feature, called bias in technological change, occurs when improvements affect only part of the production process. A new seed variety that more effectively uses fertilizer is an example. Productivity growth in this case is primarily associated with improved seeds, a subset of material inputs.

Many studies have measured the bias in technological change. Technological change in U.S. agricultural production has reduced the need for labor and land and has increased the use of agricultural chemicals and farm machinery. Labor shows the largest decline while materials show the most growth (fig. 4). Capital growth roughly equals the decline in the share of land. These biases stem from the relative costs of these inputs. For example, labor wage rates rose by roughly 4 percent a year between 1947 and 1987 compared with an average annual growth of 1.5 percent in the average price for all material inputs. The rising cost of labor relative to materials encourages the adoption of technologies which save on the use of labor and increase the use of materials. Since land is in fixed supply, it places an upper limit on expansions in production. As a result, technological innovations have been developed which save land and lessen restrictions made by the limited supply of land. The innovations in turn slow the growth in land values by making land relatively less important in agricultural production.

Figure 4—Input use bias due to technological change.
Technological change has favored materials and capital and has reduced the dependence on land and labor.



Biases are measured as percentage change relative to materials.

Technology Can Improve U.S. Export Competitiveness

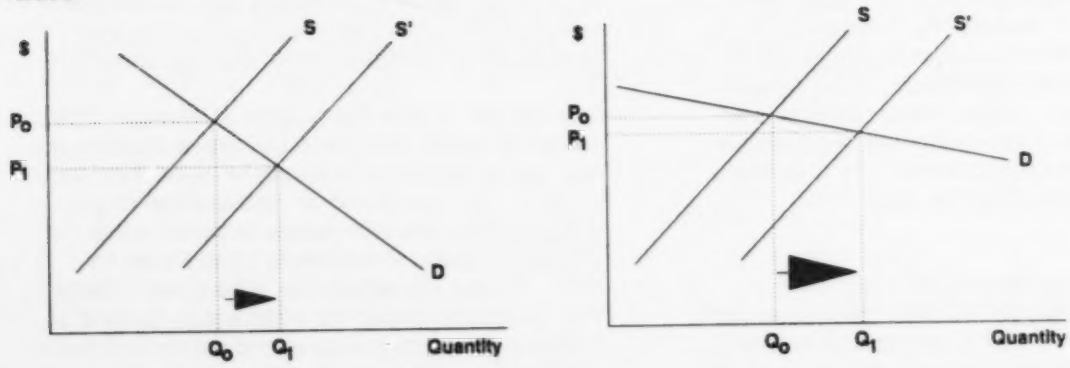
Technological progress lowers the costs of agricultural production and thus improves competitiveness of U.S. exports. Expanding export market shares raise net returns and ultimately land values.

Technological progress can lower the cost of internationally traded goods by lowering costs of production. Lower production costs relative to other countries implies U.S. commodities can be sold at a lower price and potentially capture a larger share of the world market. A larger market share means greater total returns and higher land values. How long the United States gains exclusively from the technological progress depends on whether and how quickly the technology is transferred to other countries and on whether and to what extent other countries innovate.

The nature of the demand for agricultural exports determines whether or not the benefits of technological progress actually occur (fig. 5). If world demand is unresponsive to changes in the supply of U.S. agricultural commodities, increases in U.S. supply due to technological changes will only lower world commodity prices and put downward pressure on land values (panel A, fig. 5). On the other hand, if world demand is highly responsive to changes in U.S. supply, then prices do not fall as much and the quantity sold will be greater (panel B). This gain in market share increases total returns and thus land values.

Increased competition in the world market during the recent past suggests that world demand is fairly responsive to U.S. supply changes. Increases in freer or unrestricted trade in agricultural commodities would allow us to benefit from technological progress.

Figure 5—Responsiveness of world demand to changes in U.S. supply.
If world demand is responsive, more U.S. supply boosts U.S. export market share and adds to land values.



World demand for U.S. agricultural products

Unresponsive to U.S. supply

A. Price falls and quantity consumed increases.

Responsive to U.S. supply

B. Price falls less and quantity consumed increases more. Under these conditions, increases in supply from technological progress can improve U.S. market share.

Agricultural Policies Counteract Technology's Effects on Land Values

Acreage reduction programs support land values about 7 percent above what they would have been in the free market. The program-induced increases in land values and the restrictions in land use generate further land-saving technological changes.

While overall economic growth and technological change provide the overriding determinants in the longrun development of land values, Government agricultural policies also have an important influence on agricultural land values. U.S. agriculture is characterized by pervasive Government intervention in land and commodity markets. The Government can alter the choice of commodities produced and inputs used through commodity price supports which favor certain commodities and acreage reduction programs which affect the level and mix of inputs used. If a policy objective is to maintain returns to the sector, then the effects of technology that would tend to depress returns must be overcome.

U.S. agricultural support policies have long sought to maintain a prosperous and productive farm sector through various forms of Government intervention. For grains such as corn and wheat, which are the economically significant field crops, programs restricting the use of land through retirement, diversion, or set-aside have been implemented. The goals of acreage reduction programs are to control output, raise prices, and increase revenue to farmers. These policies have slowed the transfer of labor and capital out of production agriculture and into other sectors of the economy where the resources could be used more efficiently.

Since the 1950's, acreage control programs coupled with support prices have created an artificial scarcity of land. Land has become scarce in the sense that landowners would supply more land based on returns expected at price support levels. The artificial scarcity is estimated to have held land's value 7 percent above what it would have been in the absence of acreage restrictions. (Based on research in Offutt and Shoemaker, 1988.) The 7-percent addition to land values is only from acreage reduction programs. Direct Government payments, such as deficiency payments and paid land diversions, and the price-stabilizing effects of Government-owned stocks would contribute even more to land values (fig. 6).

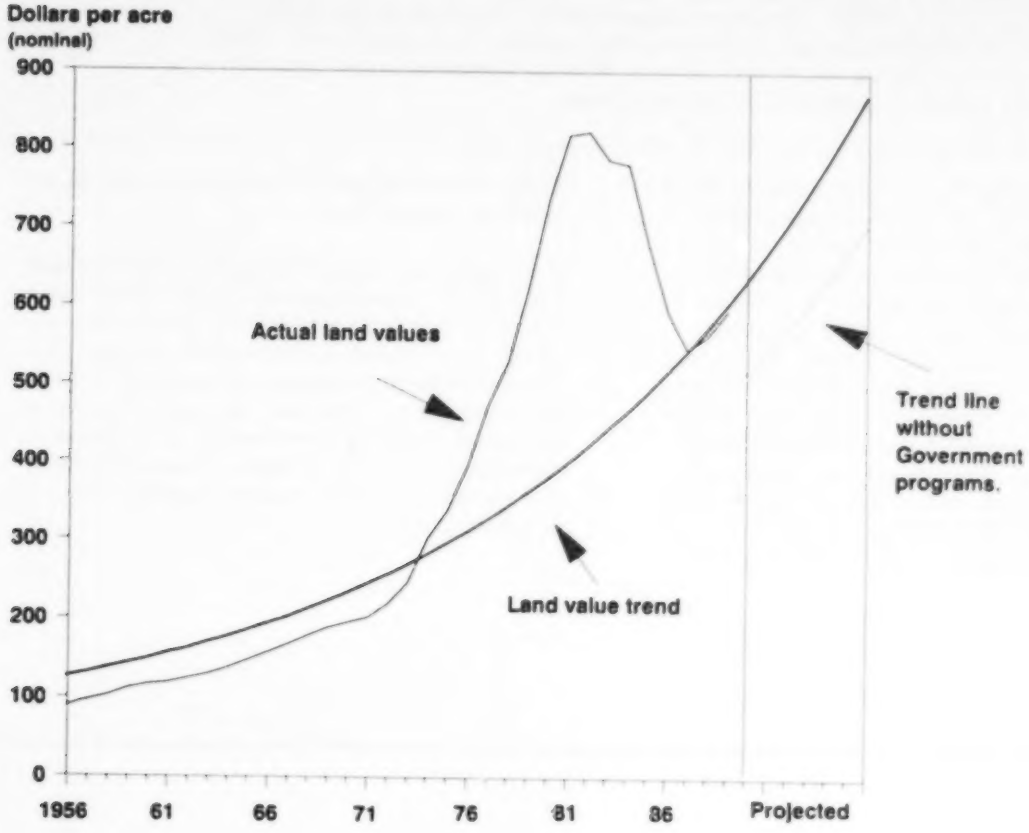
Acreage Controls Promote Land-Saving Technologies. Acreage reduction programs also affect the direction of bias in technological change, adding to its downward pressure on land use in agriculture. The acreage controls cause a relative increase in land's price. This leads to the adoption of more land-saving technologies than might have otherwise been the case, to save on the costs of using land and to use it more efficiently.

Acreage diversion programs may have at least partially offset the economic forces that diminish land's share in agricultural production. At the same time, the programs have contributed to the reduction in the shares of capital and labor, while the share of materials has risen in an effort to maintain production levels. The estimated increase in materials' share is consistent with the supposition that producers use more inputs other than land, such as fertilizers, under acreage controls.

Landowners receive the benefits of acreage control programs rather than wage earners or capital owners, mainly because the supply of agricultural land is fixed. The conversion or capitalization of program benefits into land values depends partly on producers' ability to substitute other inputs for land. If there are substantial substitution possibilities, producers substitute other inputs for land as program payments increase land values and costs of using land increase. Substitution of other inputs for land increases the returns to those inputs.

The ability to receive payments as a program participant is partially capitalized into the current value of the land. Consequently, program benefits represent windfall gains to current landowners, who have an incentive to support the continuation of these programs.

Figure 6—Land values are higher with Government programs.
Government programs have counteracted some of the effects of technological change on land values.



Potential Technological Advances in the Future Offer Important Policy Choices

Emerging technologies may increase agricultural productivity and crop output, and decrease commodity prices and land values. Policies implemented in response to the price-depressing effects of technological progress can either support farm prices and inhibit resource transfers out of the sector or take a more efficient market-oriented approach that allows resources to adjust in response to market signals.

What are the consequences of technological developments and possible directions for agricultural policy for future agricultural land values? Most recent technological innovations have centered around developments in biotechnology. These emerging technologies are projected to increase crop output by as much as 25 percent by the year 2000 for some major crops, according to the Office of Technology Assessment, U.S. Congress. With U.S. per capita demand for agricultural products growing less rapidly than supply, and demand for U.S. exports uncertain, an increase in supply could further reduce commodity prices. In the short run, Federal support programs, if left in their present status, could mitigate that decline by providing a minimum support level.

In the long run, support programs tend to inhibit the transfer of resources out of agriculture, which causes farm returns to decline. Making farm programs more market oriented could increase the benefits of biotechnological advances for producers and consumers. If farmers responded to market-generated prices for commodities and resources, productivity gains would result in greater profits and wealth rather than excess supplies and declining prices.

For more information...

Contact Robbin Shoemaker, (202) 786-1428, Economic Research Service, U.S. Department of Agriculture, Room 408, 1301 New York Avenue, NW., Washington, DC 20005-4788.

Also see...

Offutt, Susan, and Robbin Shoemaker. *Farm Programs Slow Technology-Induced Decline in Land's Importance.* TB-1745, U.S. Dept. Agr., Econ. Res. Serv., May 1988.

U.S. Congress, Office of Technology Assessment. *Technology, Public Policy and the Changing Structure of American Agriculture.* OTA-F-285, March 1986.

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